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Research Article

What Affects Safety Perception of Female Ride-Hailing Passengers? An Empirical Study in China Context

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Ride-hailing services provide an efficient way to travel, but they also cause some safety incidents, which make female passengers uneasy. Analyzing the safety perceptions of female passengers, particularly their psychological and emotional responses, can assist operators in developing effective solutions and safe travel environments for them. This study explores factors that are likely to affect the safety perception of female ride-hailing passengers using a subjective method (data was obtained from 596 Chinese female passengers). The methodologies adopted mainly include confirmatory factor analysis (CFA) and a maximum-likelihood structural equation model (ML-SEM). A passenger safety perception model is developed by considering various elements such as safety expectation, platform trust, perceived environment, and safety awareness. The results revealed that safety perception is positively influenced by perceived environment and safety expectation (containing three subdimensions, namely, driver behavior, traveling together, and mobile phone dependence). The effects of safety awareness and platform trust on safety perception are mediated by perceived environment and safety expectation, respectively. Regarding overall effects, safety expectation is the most powerful predictor for safety perception of female ride-hailing passengers, followed by platform trust, perceived environment, and safety awareness. Finally, countermeasures are offered from the perspectives of operators, drivers, and passengers to enhance the safety perception of female ride-hailing passengers. A high level of ride-hailing safety would undoubtedly boost the female passenger's trust and consequently ridership.

1. Introduction

Ride-hailing originated from combining information and communications technology (ICT) and digitized taxi operation, representing a typical outcome of "Internet +" and "sharing economy" [1]. It offers an on-demand and door-to-door mobility service, where users request (hailed), track, and pay through smartphone apps like DiDi Chuxing and Uber [2, 3]. A decade ago, it was common to see passengers struggling to hail taxis and drivers cruising empty cars in search of passengers. But now, drivers can determine the time, place, and destination of the trip in advance through communication on ride-hailing platforms with the passengers. The emergence of ride-hailing greatly eases the problems of information asymmetry and supply and demand imbalance between drivers and passengers, reduces operating costs (compared with traditional taxi services), and saves social resources [4]. Moreover, it increases the efficiency of urban transportation system [5], provides commuters with a more comfortable and time-efficient travel option, and also allows vehicle owners to access secondary jobs [6]. Thus, as a complement to or substitute for other travel modes [7], ride-hailing highly benefits both individuals and society as a whole, and it draws a big user base. According to statistics in 2020, China, in particular, has a large number of prospective consumers for ride-hailing due to low rates of private automobile ownership (18.6%). As of June 2020, the number of ride-hailing users reached 340 million, accounting for 36.2% of the country's 932 million mobile Internet users. It means that at least one out of every three mobile Internet users is a ride-hailing user [8]. However, the development space for ride-hailing is limited in other countries. The United States, for example, owns the world's second largest per capita car ownership, with approximately 812 cars per 1,000 people. More than 90% of American families own or lease a vehicle. As a result, many of them use ride-hailing services only a few times per month [9]. Nonetheless, Schaller [10] has predicted that American ride-hailing trips may overtake bus trips in the coming years. Multiple ride-hailing companies, such as Uber, Lyft, and DiDi Chuxing, operated in cities over the world [7] and are developing furiously. DiDi Chuxing, for example, has about 550 million customers and makes over 30 million rides per day in over 400 Chinese cities, making it the world's largest ride-hailing company. In San Francisco, the birthplace of Uber and Lyft, an estimated 170,000 ride-hailing trips are made each day, accounting for at least 9% of the travel market [7, 11]. However, innovation and risks are inextricably interrelated, and the same goes for ride-hailing. Most ride-hailing vehicles do not use any display sign or sticker, which makes it difficult for pedestrians or passersby to differentiate them from private vehicles [12]. Furthermore, the insufficient screening approach raises the chances of a felon getting hired as a ride-hailing driver, putting passengers at danger of theft, assault, and murder [12]. Indeed, multiple incidents have been reported on social media and traditional news media about harassment from ride-hailing drivers. Nearly 100 Uber drivers in America have been accused of sexual assault or abuse, between 2014 and 2018 [13]. In China, at least 56 cases of sexual abuse or harassment of passengers by ride-hailing drivers were reported during the same period. Users began to doubt the safety of ride-hailing services when similar occurrences were posted on social media, which makes them more careful to select their modes of transportation, particularly among female passengers who are more concerned about criminality and personal safety [14].

Personal safety of female passengers has become an issue of great concern and debate. For women all throughout the world, verbal and physical harassment in public places is a daily occurrence [15]. It undoubtedly increases the chance of female passengers being victimized, especially in a concealed place such as ride-hailing. Unsurprisingly, the fear of undergoing assault, violence, or harassment is becoming a critical factor in decision-making of travel mode, and the magnitude of these effects is always magnified for women [16]. Traditionally, women are presupposed to be vulnerable, weak in defense, and low in security, so they are more likely to express their fears and more concerned about how to defend themselves against offenders than men, especially at night [17]. On the other hand, due to the differences in social and family roles, the types of activities that men and women carry out are completely different. Compared with men, women generally travel less for work, but more for shopping and trips related to children and elder care [18]. Hence, women's travel patterns are more diverse and complex, and they prefer to be accompanied when traveling [19]. In addition, women's average income is at least 20% lower than men's [20], which means that they have less access to private cars and rely more on public transport. It also indicates that the majority of ride-hailing consumers are women [21], and the rate of women's complaints about the safety of ride-hailing services is also much higher than men's [22]. Therefore, it is of great significance to discuss the safety perception of female ride-hailing passengers, both in theory and in practice.

Based on the above, ride-hailing services have increased public mobility, but the safety of female passengers is still a hotly disputed topic in the media. Fear of victimization has major effects on women's safety perception, regardless of whether it is founded in real or merely imagined risk. As society has become more diverse and complicated, the factors influencing the safety perception of female ride-hailing passengers have grown in number. This is especially true for the new travel mode, ride-hailing. Because of the inadequacies in ride-hailing's safety management system and the unpredictability of citizens' behavior, theoretical research always lags behind the actual demand. To the authors' knowledge, studies about the impact of some psychological factors, such as passenger emotions (including fear, anxiety, relaxation, and vigilance), on the safety perception of ride-hailing services remain limited. Existing study also shows a general lack of understanding of female specific feelings and safety needs for ride-hailing services. Consideration of these matters was the source of motivation behind the present study. Whereby, this study takes female ride-hailing passengers in China as research objects to explore the factors affecting their safety perceptions. The next section provides a literature review. Section 3 proposes a hypothetical model and describes the measures, sample, and data, followed by using the structural equation model (SEM) to perform confirmatory factor analysis and verify the hypothesized model. Based on the findings, relevant solutions are proposed in Section 4. Finally, Section 5 concludes with key findings and several research suggestions.

2. Literature Review

This section provides an overview of relevant literatures related to the following: (a) travel safety perception, mainly for ride-hailing passengers, the role of gender in safety perception explaining why women were chosen as the research subject, and (b) factors affecting the safety perception of female ride-hailing passengers.

2.1. Ride-Hailing Travel Safety

2.1.1. Safety of Vehicle and Driver. The safety of vehicles and drivers is the basis of passenger travel safety, providing passengers with a safe travel environment. Many scholars have conducted related studies on this aspect. For example, Lan et al. [1] proposed that vehicle safety mainly relates to speed, regular vehicle maintenance, and security checks (including car rearview mirror, braking system, steering system, lighting, signal indicator, and tires). Findings from Useche et al. [23] indicated that driving stress and job insecurity are positively associated with traffic accidents. According to a study conducted in Chile [2], more than 15% of ride-hailing drivers resign due to insecurity (e.g., fear of confrontation with taxi drivers).

Long work durations are thought to increase the probability of traffic accidents, exposing drivers to potentially perilous scenarios on the road. Meanwhile, confessions from murderers and carjackers arrested in Lagos suggest they see Uber drivers as soft targets [24]. It shows a widespread issue:

drivers are confronted with several possible safety threats and have a poor level of safety precaution awareness. This brings certain safety hazards to passengers.

2.1.2. Passenger Travel Safety Perception. The Psychology Dictionary defines a sense of safety as “a feeling of confidence, reassurance, stability and freedom separated from fear and anxiety” [25]. It is a psychological need that desires stability and safety. A high sense of safety does not mean that the situation is safe, and further dangers may be obscured by lack of risk knowledge and safety awareness. Therefore, people’s assessment of environmental security status is abstract, vague, or uncertain, and the feelings generated are also affected by individual cognition. This leads to a deviation between the personal perception and the actual safety level of the situation [26]. The concept of safety perception, which represents a process of change in the perception of potential safety risks, is proposed to explain the safety level. It requires individuals to make subjective safety judgments through environmental stimuli based on intuitive judgment and subjective experience and ultimately guides people’s decision-making behavior [27, 28]. It means that safety perception is closely related to travel choice behavior. Hence, exploring passenger safety perception will help promote the sustainable development of ride-hailing.

In terms of travel safety perception, the safety perception of pedestrians [17, 26], metro commuters [29], and bus passengers [27] has been discussed. However, most researches on the safety of ride-hailing passengers are qualitative from the standpoint of safety supervision. For example, Chaudhry et al. [12] proposed strategies such as real-time itinerary monitoring, distress alarm, interior lighting settings, and ride-hailing label display. Yanwei et al. [5] identified technological risks in ride-hailing, such as privacy, liability, and safety, and proposed relevant governance strategies for the Singapore government. Meanwhile, some scholars have conducted researches taking safety perception as a factor affecting the choice intention of customers [1, 12, 24, 30] and the service quality of enterprises [31]. However, there are few empirical studies on safety perception from the perspective of personal psychological [32]. On the other hand, findings by Chaudhry et al. [12] show that the future of ride-hailing services depends on passengers’ safety perception and drivers’ behavioral attitudes. This is consistent with the discussion by Chowdhury [33], indicating that personal safety is the most significant issue among the dangers travelers seek to avoid while using ride-hailing services.

2.1.3. The Role of Gender in Safety Perception. Globally, it is mainly women who use public transport [27]. Almost every day, women are exposed to unwanted attention and harassment in public [28]. According to the National Institute for Women (INMUJERES), 9 out of every 10 Mexican women have been harassed at least once using public transport [22]. A Bolivian study showed that 37% of female TransMilenio passengers reported to unwanted contact [34]. Moreover, a government-led study in Washington discovered that 28% of surveyed women had experienced harassment using public transport [28]. Despite the frequent occurrence of such incidents against women’s will, the problem remains understudied and inadequately addressed. It means that in many cities around the world, women still rely on public transport, and many of them feel unsafe during their travels [27]. Furthermore, hidden spaces like ride-hailing are more likely to heighten the anxiety and uneasy of female passengers.

Men are less prone to fear victimization as a result of the social perception of masculinity norms [35], while women tend to perceive themselves as physically weaker and always magnify the interference of external uncontrollable factors on their emotions and perceived safety [16, 18]. Perceiving themselves as more vulnerable to serious injury, they are thus more prone to develop fear than men [24, 36]. Many activities related to daily life are completed by women, so it is necessary to reduce the safety risks of public space and traffic environment while also improving the public’s sense of safety [17].

Table 1 describes above papers’ finding for the relevant problems discussed in Section 2.1. It can be seen that the efficacy of safety safeguards in ride-hailing is determined upon traveler perception or viewpoint. This is exactly the background to the motivation for the current study to investigate the personal safety perception of ride-hailing passengers and its influencing factors. Furthermore, compared with men, women’s travel patterns are more diverse and complex and more reliance on public transportation. And, women are considered to be weak and disadvantaged in traditional cognition. In the face of danger, women are more likely to show anxiety and panic. Therefore, this paper selects female passengers as the research object.

2.2. Factors Affecting Safety Perception. With the diversification and complexity of society and the high unpredictability of public behavior, factors affecting safety perception of female ride-hailing passengers are becoming complex. Within criminology literature, a range of studies have examined factors affecting people’s sense of safety in multiple situations [28, 37, 38]. These factors involve environmental, sociodemographic, socioeconomic, and psychological aspects [39]. Meanwhile, we collected the questionnaire items and some interview records in the references and imported the sorted questions and interview content into an Online Word Cloud Art Creator (https://wordart.com/) to extract keywords and drew Figure 1. This provides direction for the design of the questionnaire in this paper.

Specifically, sociodemographic factors involve gender, age, education, employment, and so forth. Studies have found that women have a stronger perception of safety risks than men [7, 33]. People with poor health, physical impairments, and the aged tend to be more anxious about their personal safety [17, 40]. Additionally, people with higher education and income generally have stronger safety consciousness [30, 41]. Other sociodemographic characteristics such as nationality and race also have always been discussed [17, 27]. For instance, a study in Australia by Ratnayake [38] has shown that international students such as Asian expressed slightly higher insecurity than domestic students.

Table 1: Ride-hailing travel safety.

Problem	Paper	Findings
Safety from vehicle and driver	Useche et al. [23], Fielbaum and Tirachini [2], Ajayi [24]	Vehicles and drivers face many potential safety risks.
Passenger travel safety perception	Chowdhury and van Wee [27], Ni et al. [26]	People's assessment of the safety status of the environment is affected by the individual cognition.
	Ajayi [24], Chaudhry et al. [12], Lan et al. [1], Lee et al. [30], Shah [31]	Safety perception as a factor affecting passengers' willingness to use ride-hailing and their perception of service quality.
	Chen et al. [32], Ceccato and Loukaitou-Sideris [18]	Factors from passengers' psychological perspective.
	Chaudhry et al. [12]	The efficacy of safety provisions is determined by travelers' perception.
The role of gender in safety perception	Chowdhury and van Wee [27], Gekoski et al. (2017), Graglia [22], Kash [34], Gardner et al. [28]	Women's dependence on public transport and being prone to safety incidents.
	Chang and Wang [35], Jackson et al. [36], Ajayi [24]	Women's weakness and sensitivity.

Figure 1: Textural cloud for keywords.

According to the keywords in Figure 1, we divide individual characteristics into three categories: personal experience, personal emotion, and personal safety awareness. Studies have identified that people with victimization experience have a higher safety perception [27, 32]. People with risk tendency, overconfidence, and optimism bias are inclined towards low safety vigilance [42]. Some studies have found that anger and fear towards safety incidents affect people's judgment of safety risks, and the influence of positive emotions and negative emotions on safety perception varies considerably [43]. Moreover, a study in China stated that as the popularity of safety awareness, the stronger the individual's safety perception becomes [32]. On the other hand, studies [27, 28, 33] have found that traveling at night is more insecure than traveling during the day. Since, low visibility can lead to blind spots or shadows where criminal activities may occur [17]. Among them, the remoteness of the environment, personal familiarity with the environment, and distance and time of the journey are the main factors considered by women when traveling [27, 37].

The expectations of drivers' qualification and normative behavior, mobile phone use, and safety of traveling together are the main factors studied in previous literature (as shown in Figure 1). More specifically, the driver's age, appearance, dress, accent, and every move may cause emotional fluctuations of female passengers and even make them feel anxious and uneasy [43, 44]. A recent study also indicated that keeping contact with others through telephone calls and information sharing can reduce women's anxiety and insecurity during ride-hailing [27, 45]. Therefore, many young women routinely use their cellphones as a positive measure to relieve anxiety when passing by or staying in places deemed unsafe [33]. Meanwhile, according to Tirachini [7], 50% of females stated that they chose ride-sharing because having someone in the car besides the driver makes them feel more secure, which means that traveling in a group can reduce the vigilance of female passengers. The above literatures all illustrate a point, namely, when the reality does not meet the safety expectation, psychological discomfort ensues. On the other hand, the degree of attention to media-related information, credibility of media channels, and information processing will affect the individual trust of online platform [13]. For instance, the negative comments [20] and negative emotions [35] expressed by others on the online platform will interfere with passengers' decision-making.

Additionally, socioeconomic attributes are also important factors, mainly divided into residential environment and local economic conditions. Studies [46, 47] found that the degree of disorder, cleanliness, and community culture in the living environment could affect individuals' fear of crime. As the residential environment determines the travel scenario, it can affect passengers' perception of safety while waiting, especially female passengers [33]. And, findings from Pantazis [48] have shown that people in poorer areas feel more insecure whether they are at home or traveling. These papers discussed above have been described systematically the main factors influencing passenger safety perception. Table 2 lists and analyzes these papers by groups. It supplies a theoretical support for the following construction of the hypothesized model and the design of the survey scale.

In the existing studies, the influencing factors have been refined mainly in terms of personal attributes, travel environment, supporting facilities, and platform management. Not all factors that influence safety perception are presented, but rather, some parameters derived from the problems exist in the real travel structure. Among them, there is less exploration from the perspectives of needs, psychology, behavior, and actual conditions. The measurement indicators and scales of passenger safety perception thus need to be improved. This provides a broad space for analyzing safety perception of female passengers and explains the differences in safety perception and psychological reactions of female passengers in different ride-hailing travel scenarios.

3. Models and Methods

3.1. Conceptual Model and Hypotheses. In this paper, we comprehensively consider various factors, namely, individual and platform characteristics, travel expectation, and environmental condition, and establish the safety perception model of female ride-hailing passengers. Empirical analysis is used to verify the hypothesized model (as shown in Figure 2), quantify the safety perception of female ride-hailing passengers, and identify its influencing factors.

3.1.1. Perceived Environment and Safety Perception. Generally, the travel environment directly affects the ride experience. Traveling at night is more insecure than traveling during the day [28, 33], and individuals' vigilance and anxiety can increase accordingly. Low visibility can lead to blind spots and ineffective monitoring, thereby increasing the probability of criminal activities [17]. Moreover, there are research findings that certain environment, such as desolation [38], poor street lighting, and lack of natural surveillance [18], is common, also greatly affecting travelers' safety perception. Following this logic, we infer that female passengers' environmental perception of ride-hailing trips can positively increase their safety perception. Thus, the following hypothesis is proposed:

Hypothesis 1. Perceived environment positively influences safety perception.

3.1.2. Safety Awareness, Perceived Environment, and Safety Perception. Commonly, the perceived environment is influenced by safety awareness, that is, safety knowledge. Understanding relevant safety knowledge can help passengers improve safety awareness [32]. Meanwhile, the modeling analysis of Wang et al. [51] revealed that passengers' safety awareness positively influences safety behavior, and the relationship between them is partially mediated by perceived safety. That is, passengers' safety perception can increase due to enhanced safety awareness. Accordingly, this study proposes that in ride-hailing, female passengers' safety awareness will positively influence their perceived environment and safety perception. Therefore, the following hypotheses are proposed:

Hypothesis 2. Safety awareness positively influences perceived environment.

Hypothesis 3. Safety awareness positively influences safety perception.

Hypothesis 4. Perceived environment mediates the effect of safety awareness on safety perception.

3.1.3. Safety Expectation and Safety Perception. Safety expectation was introduced into the model, which includes the expectations of drivers' image and normative behavior, mobile phone use, and traveling together. As some studies found, when the reality does not meet the safety expectation, negative emotions such as psychological discomfort, restlessness, and anxiety ensues [7, 33, 44, 45]. And, these negative emotions commonly affect passengers' judgment of safety risks [43], thus affecting their perception of safety. Hence, we propose that female passengers with high safety expectation also have strong safety perception during the ride-hailing process. And the following hypothesis is raised:

Hypothesis 5. Safety expectation positively influences safety perception.

3.1.4. Platform Trust, Safety Expectation, and Safety Perception. Passengers' trust in the ride-hailing platform is mainly influenced by related accident reports, feedback processing, and driver qualification check [13]. Based on it, this study infers that passengers' trust in the online platform can affect their safety expectations for the actual travel by ride-hailing. Meanwhile, the higher the trust in the driver, vehicle, and platform management, the higher passengers' safety perception level will be [45]. Therefore, we propose the following hypotheses:

Hypothesis 6. Platform trust positively influences safety expectation.

Hypothesis 7. Platform trust positively influences safety perception.

Hypothesis 8. Safety expectation mediates the effect of platform trust on safety perception.

Additionally, safety awareness affects individuals' judgment ability [32], thus affecting its trust in online platforms. Meanwhile, the involvement of information such as safety accident reports and passengers' negative comments on online platforms can enrich individuals' safety knowledge [45], thus improving safety awareness. Therefore, this study proposes the hypothesis that platform trust and safety awareness interact with each other.

Table 2: Factors affecting safety perception.

Factor type	Paper	Influence factors
Demographic characteristics	Ross and Jang [40], Park and Garcia [17]	Gender, age, and physical situation.
	Armaş [41], Lee et al. [30]	Education level, income level.
	Ratnayake [38]	Nationality and race/ethnicity.
Individual characteristics	Chen et al. [32], Chowdhury and van Wee [27]	Victimization experience.
	Chowdhury [33], Chowdhury and van Wee [27]	Dependence on mobile phones.
	Simon et al. [42]	Risk tendency.
	Zuo et al. [43]	Individual emotion.
	Chen et al. [32]	Safety knowledge.
Travel status	Khoo and Ahmed [44], Zuo et al. [43]	Driver's words and deeds.
	Tirachini [7], Sarriera et al. [49]	Travel behavior.
	Sun et al. [13], Pan et al. [20], Chang and Wang [35]; Alemi et al. [50]	The credibility of online platform.
	Chowdhury and van Wee [27], Chowdhury [33], Gardner et al. [28], Park and Garcia [17]	Travel environment.
Socioeconomic factors	Oh and Kim [46], Ren et al. [47], Chowdhury [33]	Residential environment.
	Pantazis [48]	Local economic conditions.

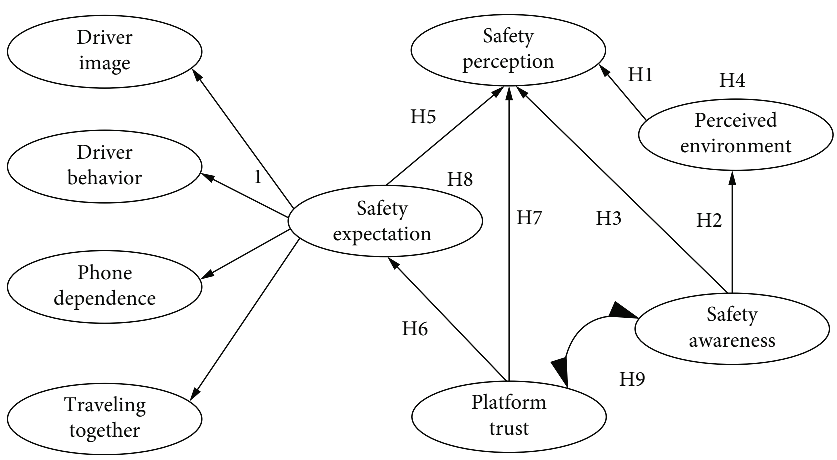

Figure 2: The hypothesized model.

Hypothesis 9. There is a correlation between platform trust and safety awareness.

3.2. Methods. Structural equation modelling was employed to validate the above research hypotheses. This method is generally regarded as the most appropriate, considering the multidimensional latent structures involved in our model [51]. Section 3.2.1 first describes data collection and sample statistics, and Section 3.2.2 conducts reliability analysis of the survey scale.

3.2.1. Sample Survey. Passenger perception data can only be obtained through limited investigation methods, such as questionnaires, observation methods, and simulation studies [26]. In this study, data regarding attitudes and behavior were collected by a combination of face-to-face interviews and online questionnaire surveys. Based on the keywords in Figure 1 and the literature findings in Tables 1 and 2, we designed a questionnaire on the safety perception of female ride-hailing passengers. Participants were mainly asked some questions about individual attributes, travel experience, and safety perception during taking ride-hailing. In the first survey conducted in October 2020, electronic questionnaire was used to distribute and collect on websites such as Tencent questionnaire. Survey response incentives used is 2 yuan per person, and 315 respondents were eligible and completed the survey. However, with the small questionnaire samples, the initial statistical results cannot fully reflect the riding conditions of Chinese female passengers, and the reliability of the research results is low. Whereby, we conducted the second survey in October 2021 to supplement the sample size and improve the representativeness and reliability of the data. Combined sample included 596 valid questionnaires, with an effective recovery rate of 79.1%. The detailed sample statistics are shown in Table 3.

Combined with the survey data, the age and education level of the investigated group are normally distributed. The majorities of respondents are 18-25 years old and hold a college degree, accounting for 62.8% and 56.0%, respectively. Of the respondents, students accounted for about half (47.3%), including high school students (9.1%), undergraduates (26.5%), and graduate students (11.7%). Practitioners also accounted for about half (43.6%), mainly including civil servants (12.9%), corporate employees (19.3%), and freelancers (11.4%). Ride-hailing users are evenly distributed among student groups and employment groups, which reflects the actual demand situation in China. Other sociodemographic survey questions covered income and residence attributes. Moreover, the majority of respondents are concentrated in southeast China, specifically distributed in Chongqing (26.8%), Hunan (6.7%), Guangdong (6.2%), and Sichuan (5.2%). This is similar to the regional distribution characteristics of ride-hailing users reported in the *Statistical Report on Internet Development in China*, that is, 54.0% in the eastern, 43.4% in the central, 44.8% in the western, and 34.6% in the northeastern.

About the ride-hailing travel experience, participants were mainly asked about the travel frequency, the main purpose of their trips, use of mobile application, and whether they experienced the safety accident. The survey shows that their use frequency of ride-hailing is normally distributed, and the software used is mainly DiDi Chuxing and third-party authorized software. Around 20% of the participants have victimization experiences, including traffic accidents, conflicts with drivers, harassment, and information leakage. The above survey results are consistent with the actual situation [8]. The respondent group includes individuals with different socioeconomic attributes, covering users in most regions of China. Therefore, the sample is relatively representative.

3.2.2. The Reliability Analysis. In the safety perception section, participants need to rate on a 5-point Likert scale (1-strongly disagree to 5-strongly agree) towards the statements presented in Table 4. These statements were abstracted from survey questions of related studies and interviews with female users. Among them, statements DI1 to DI4 are to investigate how much passengers care about the driver's image. Statements DB1 to DB5 are included to provide a deeper understanding of female passengers' discomfort caused by drivers' abnormal behavior. Statements TT1 to TT6 are from peer review and aim to explore traveling together behaviors (referring to taking ride-hailing with other passengers besides the driver) that are likely to affect female passengers' safety perception. Statements PD1 to PD6 describe the use of mobile phones during travel and reflect female passengers' dependence on mobile phones. As discussed by Chowdhury and Van Wee [27], mobile phones have played a key role in reducing anxiety among female passengers. Statements PT1 to PT6, PE1 to PE3, and SA1 to SA3 are based on findings from previous studies on the credibility of online platform [20], travel environment [27, 42], and safety awareness [32].

Measurement reliability was evaluated according to the Cronbach's alpha value. The results show that the Cronbach's alpha of each variable is between 0.793 and 0.917 (see Table 4), above 0.70 as recommended by Urbach and Ahlemann [52]. Only Cronbach's alpha of driver image variable is not qualified. After deleting this variable, the Cronbach's alpha of the total scale reaches 0.916, suggesting that the reliability of the formal scale is good.

Correlation analysis is commonly employed to examine data independence. In this paper, we adapted the SPSS statistical package to analyze the correlation of 29 measurement items presented in Table 4. The results show that statement DB5, "I feel uneasy when the driver smokes, talks on the phone, listen to the radio, etc.," is weakly correlated with statement DB1, "I feel uneasy when the driver drives too fast," and statement DB3, "I feel uneasy when the driver asks about matters in the realm of my personal privacy." And, statement PT4, "Whether the driver identity audit is strict will affect my trust in the ride-hailing platform," is also weakly correlated with statement PT3, "Passengers' evaluation of the driver is an important reference for me in using ride-hailing," and statement PT5, "Whether the driver has a criminal record is an important reference for me in using ride-hailing." It shows that data of statements DB5 and PT4 is not independent. Hence, we removed the latent variables DB5 and PT4. The other variables' absolute values of correlation coefficients are all less than 0.3 [53], which means that they are independent and can be further analyzed.

4. Results and Discussion

A structural equation model was developed using AMOS 24.0. According to Dawn [54], a maximum-likelihood estimation provided in SEM is adapted to reflect how likely independent variable observations are to predict dependent variable observations. In this analysis, the two-step approach recommended by Anderson and Gerbing [55] was applied to validate the hypothetical model. Firstly, the measurement model was evaluated through confirmatory factor analysis (CFA), followed by the fit index and path coefficient analyses of the structural model, also the test of mediation effects between variables.

4.1. Measurement Model Analyses. Firstly, to reduce the complexity of the measurement model, we conducted item deletion and dimension compression [53]. It is specific to perform the first-order CFA on six factors such as driver behavior and traveling together. According to the test result of modification indices (M.I.), the item with the highest M.I. value was adjusted or deleted [56]. For example, in the traveling together dimension, $\text{RMSEA} = 0.12 > 0.05$ [53] indicates that this construct cannot fit the data and needs to be revised. Among its observed variables, the M.I. value of item TT4 is the highest (66.904), and its factor loading is less than 0.4 [56]. Therefore, it is reasonable to delete item TT4. By analogy, until the entire model reaches the

Table 3: Survey sample demographics.

Demographic characteristics	Participants	Percentage (%)
Age		
<18	57	9.6
18-25	374	62.8
26-40	104	17.4
>40	61	10.2
Employment		
Practitioner	232	43.6
Student	282	47.3
Other	54	9.1
Monthly disposable income[a]		
<$305	254	42.6
$305-$763	195	32.7
>$763	147	24.7
Education level		
High school or below	147	24.7
College	334	56.0
Postgraduate or above	115	19.3
Travel experience	Participants	Percentage (%)
Frequency of ride-hailing use		
More than 2 times a week	134	22.5
1-2 times a week	119	20.0
1-2 times a month	220	36.9
Not in the last three months	123	20.6
Ride-hailing software		
DiDi Chuxing	430	72.1
Alipay, WeChat, and other third-party software	353	59.2
Other	153	25.7
Most frequent travel motive		
Commuting to work/school	215	36.1
Connecting with other travel modes	345	57.9
Use only when in a hurry	291	48.8
Other	90	15.1
Victim or not		
Yes	120	20.1
No	476	79.9

Note: sample size = 596; [a]1USD = 6.49 CNY in July 2021.

adaptation standard, items DB1, TT5, PD1, PD5, PT2, and PT4 were ultimately deleted, and the number of measurement items was reduced to 20.

Similarly, to compress the measurement model dimensions, we used the safety expectation dimension to replace the three factors of driver behavior, traveling together, and mobile phone dependence (see Figure 3). To verify the applicability of the alternative model [53], we used the target coefficient to validate the existence of a higher-order safety expectation construct. That is, with model 1 as the target model, the target coefficient is the chi-squared ratio between model 1 and model 2. In our case, a target coefficient of .99, close to 1, means that 99% variation of three first-order factors in model 1 can be explained by the safety expectation construct in model 2 [53, 57]. Therefore, it is feasible to take the second-order CFA to perform next structural model analysis in this research.

Next, measurement model fit was analyzed performing CFA (see Table 5). In specific, the model reliability and validity were assessed according to the standardized coefficients (λ), t-values, average variance extracted (AVE), and composite reliability (CR) [51, 52]. The results reveal that the CR values are between 0.761 and 0.919, above 0.6 recommended by Urbach and Ahlemann [52]. Therefore, the internal consistency of the measurement model is validated, suggesting that all latent constructs can be effectively represented by the proposed observed variables. Meanwhile, the AVE values are between 0.481 and 0.790, most of which

Table 4: Reliability analyses of formal scale.

Factors	Observed variables	Statements	Cronbach's alpha
Driver image	DI1	I am very concerned about the driver's age.	0.596
	DI2	I am very concerned about the driver's gender.	
	DI3	I am very concerned about the driver's appearance.	
	DI4	I am very concerned about the driver's accent.	
Driver behavior	DB1	I feel uneasy when the driver drives too fast.	0.793
	DB2	I would be uneasy if the driver takes a detour without telling me.	
	DB3	I feel uneasy when the driver asks about matters in the realm of my personal privacy.	
	DB4	If the driver looks at me consciously or unconsciously, I will feel uneasy.	
	DB5	I feel uneasy when the driver smokes, talks on the phone, listen to the radio, etc.	
Traveling together	TT1	Taking a ride-hailing by yourself requires more vigilance than if you had a friend with you.	0. 817
	TT2	Traveling with acquaintances is safer than carpooling with strangers.	
	TT3	It is safer to carpool with women than with men.	
	TT4	Traveling with a male friend is safer than traveling with a female friend.	
	TT5	The more people you travel with, the safer you are.	
	TT6	I'm wary of traveling alone with my children.	
Mobile phone dependence	PD1	Having an emergency contact makes me feel safe.	0.846
	PD2	Recording the entire journey makes me feel safe.	
	PD3	Sharing information about drivers, cars, routes, etc. makes me feel safe.	
	PD4	During the ride, I check the driver's route by looking at a map.	
	PD5	During the ride, I usually play with my cell phone or make a phone call.	
	PD6	During the ride, I would feel uneasy if my cell phone had no power or signal.	
Platform trust	PT1	I was angry and scared about the reports of ride-hailing safety incidents.	0.894
	PT2	Reports of safety incidents related to ride-hailing prompted me to take defensive action.	
	PT3	Passengers' evaluation of the driver is an important reference for me in using ride-hailing.	
	PT4	Whether the driver identity audit is strict will affect my trust in the ride-hailing platform.	
	PT5	Whether the driver has a criminal record is an important reference for me in using ride-hailing.	
	PT6	The handling results of passenger complaints affect my trust in the ride-hailing platform.	
Perceived environment	PE1	I avoid using ride-hailing alone at night.	0.917
	PE2	I avoid using ride-hailing alone in remote suburbs.	
	PE3	I avoid using ride-hailing alone in a strange place.	
Safety awareness	SA1	I know that using ride-hailing involves certain personal safety risks.	0.823
	SA2	I know there is a risk of information leakage.	
	SA3	I know that drivers who use cell phones while driving increase the risk of accidents.	
Safety perception	TS	I am worried about traffic safety accidents during ride-hailing trips.	0.892
	IS	I am worried about personal privacy leaks and information theft.	
	PrS	I am worried about money being stolen or robbed during ride-hailing trips.	
	PeS	I am worried about intentional injury, rape and other violent crimes during ride-hailing trips.	

Note: (1) $N = 596$; (2) TS: traffic safety; IS: information safety; PrS: property safety; PeS: personal safety.

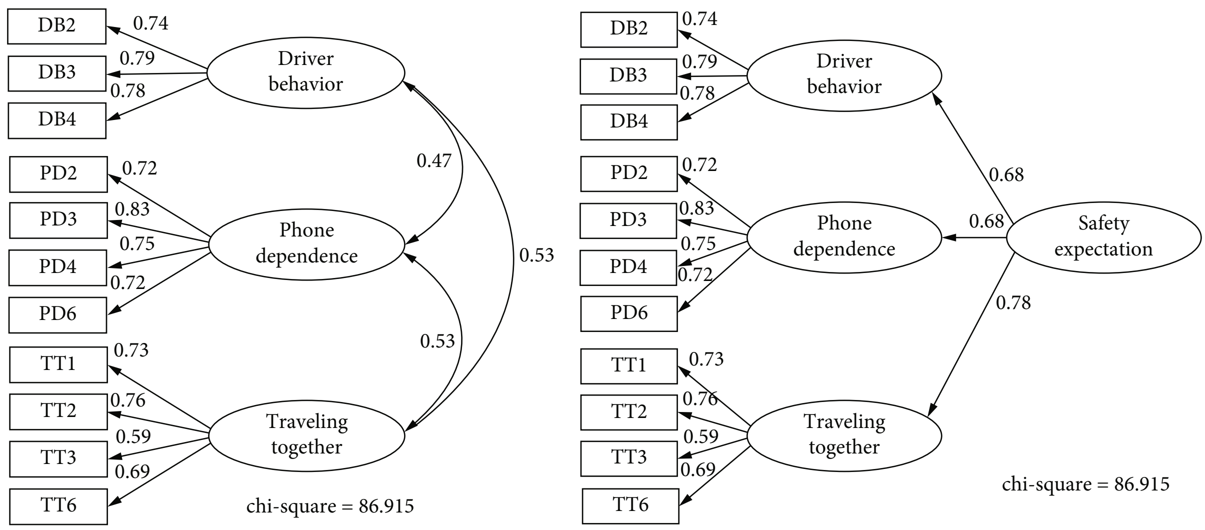

Figure 3: Alternative models.

are above 0.5 recommended by Fornell and Larcker [58] and the level at which most variables are accepted [54]. This supports the convergent validity of the measurement items.

These findings from Table 5 also show that each observed variable can well reflect its corresponding latent variable. Specifically, for driver behavior, item DB3 has the highest loading (0.789), indicating that female passengers are quite sensitive to the driver behavior of asking about personal privacy. Around 79% of participants agreed with this statement. Regarding mobile phone dependence, item PD3 (0.831), information sharing, is the most likely action for female passengers and can best relieve their anxiety in the face of emergencies. For the observed variables of traveling together, items TT1 and TT2 have similar weights, 0.741 and 0.747. This finding is reasonable as female passengers generally present a high perceived safety while traveling with acquaintances. The above three factors all reflect the safety expectation of female passengers from different angles. Among them, traveling together has the greatest effect on meeting safety expectation (0.778). This finding is consistent with the actual survey result that 76.7% of participants felt that traveling together is safer than traveling alone.

Regarding platform trust factor, the λ values of all observed variables are all above 0.65, with item PT5 showing the highest loading, 0.812 (Table 5). This finding shows that relevant reports on safety accidents, negative comments on drivers, and driver background are all concerns for female passengers and affect their trust in the ride-hailing platform. Among the observed variables of safety awareness, item SA2 holds a slightly higher load than the other two items, which is reasonable as the information leakage of ride-hailing passenger often occurs in China [32, 59]. Regarding the observed variables of the perceived environment, their loadings are all high, with item PE1 showing the highest loading (0.929). This is aligned with the finding of the previous studies that female passengers are more vigilant and sensitive to safety risks when traveling alone at night [32, 45]. In addition, in terms of safety perception dimensions, their loadings have similar weights and are all high above 0.80. Among them, personal safety (PeS, 0.854) is most concerned by female passengers. This finding aligns with the actual investigation, where around 58.7% of participants agreed with this statement.

Furthermore, common method bias was also measured considering that our data were collected from questionnaires. In the case, Harman's single-factor method is suitable for testing whether certain factors account for over 50% of measurement model variance [60]. The result shows that the variance of single-factor model is about 34.84%, and all variables explain 71.16% of the variance in safety perception. The small proportional variance explained by the single-factor model indicates that common method bias is unlikely to be a major concern in our research [51].

Accordingly, it can be concluded that the measurement model fits the data well, and its reliability and validity are supported. Also, the method bias is not a major issue.

4.2. Structural Model Analysis. Commonly, goodness-of-fit measures are applied to verify the reliability and validity of structural model. Specifically, absolute indices of goodness-of-fit such as chi-square, goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), and root mean square residual (RMSR) were adapted to assess model robustness [54]. Relative or incremental fit indices reflect the fit improvement of one model over an alternative, including comparative fit index (CFI), normed fit index (NFI), and Tucker-Lewis index (TLI) [36, 53]. In this study, the analysis results are presented in Figure 4. That is, $\text{chi}-\text{square} = 626.030$, degrees of freedom $(\text{df}) = 265$, $\text{RMSEA} = 0.048 < 0.05$, $\text{CFI} = 0.952$, $\text{TLI} = 0.946$, $\text{GFI} = 0.922$, and $\text{NFI} = 0.920$. These model fit indexes are all above recommended level 0.9 [52], which means that results are robust to the use of structural equation model. Furthermore, this model explains over 50% of variances in endogenous variables (i.e., driver behavior, phone dependence,

Table 5: The reliability and validity analyses of observed variables.

Factors	Items	Significance estimation S.E.	*t*-value	*p*	Standardized coefficients λ	Composite reliability CR	Convergent validity AVE
Safety expectation	DB	Unstandardized			.672	.759	.513
	TT	.124	9.732	***	.778		
	PD	.116	9.361	***	.695		
Driver behavior	DB2	Unstandardized			.742	.813	.592
	DB3	.063	16.703	***	.789		
	DB4	.063	16.576	***	.777		
Traveling together	TT1	Unstandardized			.741	.786	.481
	TT2	.062	15.831	***	.747		
	TT3	.067	12.774	***	.585		
	TT6	.056	14.856	***	.690		
Mobile phone dependence	PD2	Unstandardized			.716	.843	.573
	PD3	.058	17.909	***	.831		
	PD4	.057	16.510	***	.748		
	PD6	.059	16.115	***	.728		
Platform trust	PT1	Unstandardized			.708	.835	.561
	PT3	.062	14.913	***	.674		
	PT5	.061	17.553	***	.812		
	PT6	.060	17.226	***	.792		
Perceived environment	PE1	Unstandardized			.929	.919	.790
	PE2	.028	33.569	***	.907		
	PE3	.032	28.317	***	.828		
Safety awareness	SA1	Unstandardized			.779	.818	.600
	SA2	.060	17.862	***	.789		
	SA3	.056	17.312	***	.756		
Safety perception	TS	Unstandardized			.803	.890	.670
	IS	.047	21.313	***	.809		
	PrS	.048	21.247	***	.807		
	PeS	.050	22.681	***	.854		

Note: (1) SE: standard errors; $^{***}p < .001$; $N = 596$. (2) DB: driver behavior; TT: traveling together; PD: mobile phone dependence; TS: traffic safety; IS: information safety; PrS: property safety; PeS: personal safety.

traveling together, perceived environment, and safety perception), which is considered high in related studies [51, 60]. This suggests that model variances are mainly explained by exogenous variables rather than error terms [52].

The results presented in Figure 4 also show acceptable values for the path coefficient of latent variables. It is found that female passengers' safety expectation and perceived environment have positive and significant effects on their safety perception. Their standardized coefficients are 0.35 ($p < .001$) and 0.14 ($p < .01$), respectively. Hypothesis 1 and Hypothesis 5 are thus shown to be supported. These findings align with the previous studies [18, 38] which show that travel environment generally affects safety perceptions of travelers while in transit. Meanwhile, safety awareness directly and positively influences perceived environment level with influence strength of 0.47 ($p < .001$). This is consistent with the previous research findings that passengers with higher safety conscious are more sensitive to the environment [32, 51]. Platform trust positively influences safety expectation with standardized effect of 0.70 ($p < .001$). Accordingly, Hypothesis 2 and Hypothesis 6 are accepted. In addition, the correlation value of 0.61 between platform trust and safety awareness indicates that Hypothesis 9 is acceptable.

4.3. Mediation Effects. To estimate the mediating effects between latent variables [54], we performed percentile bootstrapping and bias-corrected bootstrapping at 95%

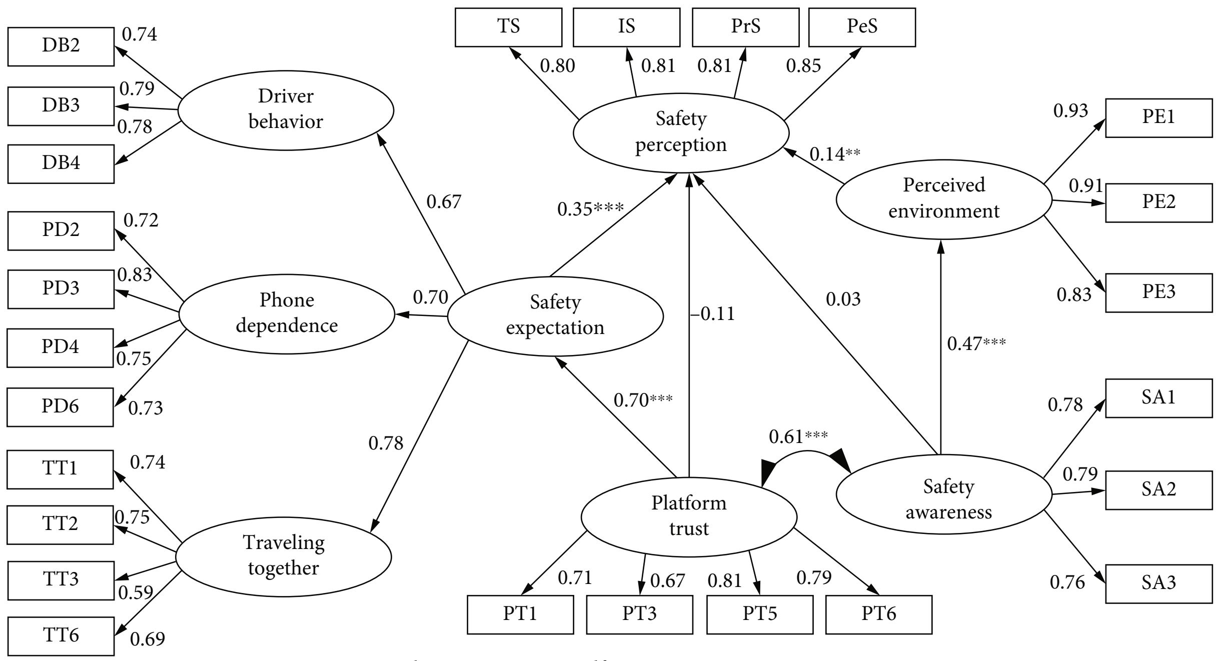

FIGURE 4: Standardized path coefficient for the structural model (note: $^{***}p < 0.001$ and $^{**}p < 0.01$).

TABLE 6: Standardized direct, indirect, and total effects.

Standardized	Point estimate	Product of coefficients		Bootstrapping Bias corrected 95% CI		Bootstrapping Percentile 95% CI		Two-tailed significance
		SE	Z	Lower	Upper	Lower	Upper	
Direct effects (a_{ij})								
PT ⟶ SE	.478	.073	6.547	.346	.630	.341	.624	.000***
SA ⟶ PE	.654	.080	8.175	.493	.811	.495	.812	.000***
PT ⟶ SP	-.140	.138	-1.014	-.426	.120	-.427	.120	.295
SA ⟶ SP	.033	.103	0.320	-.152	.254	-.161	.242	.709
SE ⟶ SP	.650	.219	2.968	.258	1.103	.281	1.132	.001**
PE ⟶ SP	.116	.051	2.275	.017	.220	.014	.216	.027*
Indirect effects (b_{ij})								
PT ⟶ SP	.310	.109	2.844	.136	.569	.134	.565	.000***
SA ⟶ SP	.076	.035	2.171	.013	.152	.009	.146	.027*
Total effects (c_{ij})								
PT ⟶ SP	.310	.109	2.844	.136	.569	.134	.565	.000***
SA ⟶ SP	.076	.035	2.171	.013	.152	.009	.146	.027*
SE ⟶ SP	.650	.219	2.968	.258	1.103	.281	1.132	.001**
PE ⟶ SP	.116	.051	2.275	.017	.220	.014	.216	.027*

Note: (1) standardized estimating of 5000 bootstrap sample; SE: standard errors; $Z = (\text{point estimate/SE}) > 1.96$; $^{***}p < .001$, $^{**}p < .01$, and $^{*}p < .05$. (2) Platform trust (PT, 1); perceived environment (PE, 2); safety awareness (SA, 3); safety expectation (SE, 4); safety perception (SP, 5).

confidence intervals with 5000 bootstrap samples of 596 responses in this model [61, 62]. Direct, indirect, and total effects in the structural model were assessed based on these samples. The results are shown in Table 6, for the indirect effects on safety perception, platform trust contributes with the largest influence strength ($b_{15} = 0.310$), followed by safety awareness ($b_{35} = 0.076$). The relationship between platform trust and safety perception is fully mediated by

Table 7: Preventive behaviors for female passengers.

Preventive behaviors	Specific examples
Avoidance behaviors	
Avoiding traveling at certain times	Avoid night alone travel.
Avoiding traveling to specific destinations	Such as deserted parking lots, poorly lit stations, and closed areas.
Avoid carpooling with strangers	Especially strangers of the opposite sex.
Protective behaviors	
Choose a safe seat	Sit directly behind the driver, not the copilot.
Hide information about yourself	Do not divulge your money or identity information.
Master relevant information	Vehicle information; driver information such as whether the driver is qualified and has criminal history; carpooler's information; driving routes.
Keep the phone connected	Get in touch with others; share information about drivers, cars, and routes with others.
Travel accompanied by another	Travel with friends or family; ridesharing with passengers of the same sex.
Emotion and expression management	Pretend to be confident and calm.

safety expectation of passengers. It means that the higher the credibility towards ride-hailing platform, the higher passengers' safety expectation for the service, and the stronger their safety perception. Similarly, the relationship between safety awareness and safety perception is fully mediated by perceived environment, suggesting that the effect of safety awareness on safety perception is generally revealed under the stimulus of the environment. The above results support Hypothesis 8 and Hypothesis 4 but reject Hypothesis 3 and Hypothesis 7. This is somewhat different from the ones by Chen et al. [32] who found that safety awareness had a direct effect on safety perception.

Through analyzing the total effects on safety perception, we found that safety expectation contributes with the largest positive effect ($c_{45} = 0.650$). This indicates that female passengers with a strong safety expectation for ride-hailing services have a higher safety perception, as they have a strong vigilance with respect to safety risks. Platform trust has the second largest positive effect on the safety perception of female ride-hailing passengers ($c_{15} = 0.310$). This is mostly due to that the highly reliable online platform meets certain safety expectations of passengers, thereby enhancing their safety perception [50, 63]. Followed by the perceived environment ($c_{25} = 0.116$), it suggests that the safety perception of female ride-hailing passengers also increases with positive recognition of the travel environment. Finally, there is also a small but statistically significant association between safety awareness and safety perception ($c_{35} = 0.076$). This suggests that female passengers have relatively weak safety awareness in ride-hailing as the lack of safety knowledge education on this new mode of travel [32].

5. Conclusions

5.1. Summary. This study adopted CFA and SEM to analyze and quantify the safety perception of female ride-hailing passengers. The analyses used data collected in China, where ride-hailing services constitute a significant share, and identified factors that affect the safety perception of female passengers during ride-hailing. This provides decision-makers with useful insights into upgrading and aligning ride-hailing services based on users' safety needs.

Through empirical analysis (using IBM SPSS Statistics and AMOS), we demonstrated that the model established in this study is reliable and can be utilized to assess the level of perceived ride-hailing safety. This model integrated travel safety expectation of individuals, trust of online platform, safety awareness, and attitudes towards the travel environment. The safety expectation for ride-hailing is mostly influenced by three factors: driver behavior, mobile phone use, and traveling together. The results of the study show that the safety expectation (0.270) of female ride-hailing passengers has the most direct influence on their safety perception. The expectation of traveling together is the strongest predictor (0.78), which explains why most female passengers prefer to travel with others [7]. The credibility of online platform has second largest effect on safety perception (0.187), followed by perceived environment (0.136) and safety awareness (0.063). Among them, the effects of platform trust and safety awareness on safety perception are, respectively, mediated by the safety expectation and perceived environment. In addition, for safety dimensions, female passengers are the most sensitive to personal safety, followed by information safety. In particular, their concerns about personal safety are mainly in relation to two aspects: (1) fear of physical injuries due to conflicts with drivers and (2) concern about robbery, rape, or intentional injury and other vicious crimes occurring during the ride-hailing process [64, 65]. And worries about information safety are also mainly reflected in two aspects: (1) personal identity information being stolen and used illegally and (2) being tracked, stalked, or harassed after the information has been leaked [59, 66].

5.2. Recommendations. Given that perceived environment, safety expectation, safety awareness, and platform trust are the factors that passengers can personally experience and intuitively perceive, safety perception is also a subjective feeling and cognition of matter. It means that in some psychological activities related to safety perception of ride-hailing, female passengers tend to make more use of subjective thinking and personal experience. This causes a phenomenon where the effects of victimization fear on female passengers' decision-making behavior are always magnified [18]. Thus, it is critical to supply female ride-hailing passengers with the necessary skills and resources to reduce their existing anxiety and insecurities. For this, we proposed recommendations in consideration of three aspects: stewardship in enterprise, driver supervision, and passengers' defense awareness.

From the perspective of enterprise management, we should first attach importance to passenger information security, take technical measures to strengthen information protection, and prevent user information leakage and embezzlement. Secondly, managers should invest in improving the user complaint mechanism. It is necessary to keep an eye on comments and complaints from passengers, deal with negative messages in a timely manner, and punish drivers who violated laws or close their accounts. Secondly, enterprises need to improve technical security capabilities, including on-board real-time monitoring and intelligent alarm systems and automatically recognizing sensitive words, so that abnormal emergencies are handled in a timely manner. It is also possible to provide women-only bus services by having female drivers. Finally, considering female passengers' dependence on mobile phones, ride-hailing can be equipped with power supply and wireless network to ensure that passengers can always keep in touch with others and reduce their psychological anxiety.

To improve the driver supervision system, the first step is to implement the access system, strengthen the verification of drivers' identities, and check their criminal records and personal credit information. Since the emotion state and driving behavior of drivers are the most intuitive basis for female passengers to make safety judgments, the working state of drivers can be regularly evaluated through the e-learning platform to ensure that their speech and behavior meet acceptable standards.

In addition, we also developed countermeasures for female passengers so that they can build a stronger awareness of prevention and control and be more confident in dealing with safety risks. Specifically, some preventive behaviors that passengers can take when ride-hailing are proposed, as shown in Table 7.

The complexity and diversity of social culture affect the urban public transportation system. In developing and developed countries, the impact of ride-hailing on increasing mobility is also different. Still, the recommendations above are universally applicable, especially to countries with conditions similar to China's.

5.3. Limitations. Admittedly, these findings need to be interpreted in light of the research limitations. Firstly, there are improper and incomplete aspects in the design of the questionnaire. For example, the design of observed variables of traveling together mostly relied on the summary of interview materials and literatures. It lacked a strict theoretical basis, which may lead to a deviation in research results. To better understand the impact of companion behavior on female passengers' safety perception during ride-hailing, it is worth further exploration on this topic.

Furthermore, this study ignores the effect of passenger heterogeneity on their safety perception of ride-hailing. In fact, there are differences in the safety perception among female passengers of different ages, incomes, educational levels, and personalities. Therefore, future studies can combine individual heterogeneity to explain passengers' safety perceptions differences. Finally, ride-hailing is a nationwide travel service platform, and the research of safety perception also needs to consider the differences in geographical and cultural factors in different regions. Therefore, future research can introduce these variables to do further exploration.

Data Availability

The data used to support the findings of this study have not been made publicly available because these data relate to third party privacy and there is a data confidentiality agreement with the data provider.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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